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ABSTRACT

This digest examines a recent study by Project 2061, which evaluated high school biology textbooks and their relationship to national standard to see if they could help students meet guidelines for scientific literacy. Suggestions for actions that teachers can take and resources for further study are included. (MM)

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Digest

High School Biology Textbooks do not Meet National Standards

David L. Haury

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Apparently bigger is not better when it comes to selecting biology textbooks. That is the conclusion of a recent study by Project 2061, the ongoing science and mathematics education reform effort of the American Association for the Advancement of Science (AAAS, 2000). Following the publication of guidelines for what scientifically literate students should know and be able to do (AAAS, 1989, 1993), Project 2061 began developing a curriculum-materials analysis process (Kulm, Roseman, & Treistman, 1999) to determine the degree to which science and mathematics textbooks are aligned with the *National Science Education Standards* established by the National Research Council (NRC, 1996), *Benchmarks* (AAAS, 1993) and other standards. Previous reports of the Project 2061 group have focused on science textbooks for the middle grades (Roseman, Kesidou, Stern, & Caldwell, 1999), mathematics textbooks for the middle grades (AAAS, 1999), and algebra textbooks (Kulm, 2000) (Available online at *www.project2061.org/newsinfo/research/textbook/index.htm*). All four studies found serious weaknesses in the science and mathematics textbooks evaluated, the most widely used science and mathematics textbooks in American schools. These are sobering findings given the extent to which teachers use textbooks to guide instruction and determine curriculum content (Association for Supervision and Curriculum Development, 1997).

Evaluation Process

Two independent teams of biology teachers, science curriculum specialists, and professors of science education evaluated each of ten leading biology textbooks and teacher guides. (AAAS, 2000) using a benchmarks-based process (Kulm & Roseman; 1999). For more details on the evaluation teams, see the description online at *www.project2061.org/newsinfo/research/textbook/hsbio/about.htm*. The evaluation process included both content analysis and instructional analysis.

Content analysis focused on the alignment of textbok content with selected learning goals from *Science for all Americans* (AAAS, 1989), the *National science education standards* (NRC, 1996), and the *Benchmarks for science literacy* (AAAS, 1993). Textbook content relating to learning goals in the following topic areas were examined:

- Cell structures and functions
- Matter and energy transformations
- Molecular basis of heredity
- Natural selection and evolution

For more detail regarding the specific content analyzed, see the report by AAAS (2000, p. 202) or view the key ideas online at *www.project2061.org/newsinfo/research/textbook/hsbio/ideas.htm*.

Instructional analysis included an examination of each textbook's instructional design using criteria derived from research on learning and effective teaching, as well the knowledge of experienced teachers. Analysis focused on only those textbook activities and lessons that are aligned with the identified content learning goals, and evaluators used criteria within the following categories:

- Providing a sense of purpose
- Taking account of student ideas
- Engaging students with the relevant phenomena
- Developing and using scientific ideas
- Promoting student thinking about phenomena, experiences and knowledge
- Assessing progress
- Enhancing the science learning environment

For more detail regarding the specific criteria used, see the report by AAAS (2000, p. 201) or view the key ideas online at *www.project2061.org/newsinfo/research/textbook/hsbio/criteria.htm*.

Major Findings

None of the evaluated textbooks was given high ratings. Following are examples of common problems (AAAS, 2000):

- In designing activities and questions, textbooks fail to take into account the research that shows essentially all students having predictable difficulties grasping many ideas covered in the textbooks.
- Textbooks ignore or obscure many of the most important concepts by focusing instead on technical terms and trivial details that are easy to test.
- The lavish illustrations of textbooks "are rarely helpful because they are too abstract, needlessly complicated, or inadequately explained."
- Students are given little help in interpreting the results of activities in terms of the science concepts to be learned.

Graphic summaries of the content analysis results can be downloaded in PDF format at *www.project2061.org/newsinfo/research/textbook/hsbio/findings.htm*, and charts illustrating the findings of the instructional analysis can be downloaded at *www.project2061.org/newsinfo/research/textbook/hsbio/charts.htm*.

What seems most striking from content analysis is the omission of some key concepts in the topics examined, and the general lack of connections made among the key ideas of biology. For instance, in the category of cell structures and functions, the key idea that various organs and tissues function to serve the needs of all cells for food, air, and waste removal is typically omitted. In the treatment of the molecular basis of heredity, the idea that an altered gene may be passed on to every cell that develops from it is typically omitted. Within the topic of natural selection and evolution, the key idea that heritable characteristics influ-

SE 064 314

ence how likely an organism is to survive and reproduce is typically omitted. In this same category, there is a set of important supporting ideas about the nature of scientific theories and how evidence is gathered and interpreted that is typically omitted.

In reviewing the results of the instructional analysis, it is immediately obvious how profoundly dominant the poor ratings are for every textbook in every category. There are few exceptions. Of the 91 data points for each textbook, none received a rating higher than "fair" on more than 28 of the factors examined. All but one textbook received a rating of "poor" on 63 or more of the 91 criteria considered. The only unconditional "excellent" ratings were given to three textbooks for "conveying unit purpose" in a topic area. No book received this rating for more than two of five topic areas. Every textbook received uniformly "poor" ratings for every criterion in the category "taking account of student ideas." Ironically, despite decades of emphasis on experiential learning in science, few textbooks earned a rating above "poor" on any criterion related to "engaging students with relevant phenomena" in any topic area other than natural selection and evolution. Perhaps we should declare all topics in biology controversial.

Actions Teachers Can Take

In addition to the longstanding admonition for science teachers to avoid relying solely on textbooks to define and structure the curriculum, here are some specific recommendations by the textbook evaluators (AAAS, 2000):

- Use trade books on science topics to enhance your own understanding and compensate for lack of content coherence in textbooks.
- Study the research on student learning cited in the evaluation reports to enrich classroom activities and develop new ones.
- Participate in professional development opportunities that include attention to both knowledge of key ideas in biology and strategies for teaching those ideas more effectively.
- Encourage support for curriculum development efforts that focus on creating a coherent picture of key ideas for specific biology topics, "using a research-based development and testing process to ensure that the instructional strategies promote learning the key ideas" (p. 200).

Action of a more immediate nature includes helping students get more meaning out of the textbooks currently in their classrooms. Acknowledging the difficulties in learning from textbooks, Ulerick (2000) suggests some alternative ways to use and learn from textbooks. She suggests that the most powerful strategy is to give students more meaningful purposes for reading textbooks, such as: (a) obtaining background or explanatory information for projects; (b) obtaining data, or (c) challengingtheir own ideas with new viewpoints. In short, present reading as a way of obtaining answers to their questions. One way to make this process more effective is to help students generate questions themselves from classroom experiences.

Ulerick also suggests using graphic strategies, such as concept mapping and related techniques, to assist students in visualizing how key ideas are related to each other. Given the particular weakness of textbooks in promoting the connections among ideas, this seems a particularly important strategy. It is further suggested that "students' personal 'maps' of ideas can be related to text readings. Prior to reading, students can map their understanding of how concepts…are related to a particular topic. As they read, they can add to their map or revise it, in light of the information presented. Or they can make a map of the reading and compare it to their own." For more strategies, see Ulerick (2000) online at www.narst.org/research/textbook2.htm.

In the final analysis, it is crucial to realize that our current biology textbooks have many shortcomings and cannot be relied upon to provide the sole content and structure for biology instruction at the high school level. Teachers must take on the responsibility of contextualizing the role of textbooks within effective instructional practices that include enriching activities, purposeful reading, and a questioning attitude. Beyond participating in ongoing professional development and continually supplementing textbook resources with other materials, teachers are encouraged to become familiar with the key ideas in biology that are identified by the *National Science Education Standards* (NRC, 1996) and other reform documents and take action to ensure that their students engage those ideas.

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